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BASIC GRADING RULES AND WORKING STRESSES FOR STRUCTURAL TIMBERS.

As Recommended by the Department of Agriculture.

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INTRODUCTION.

The Forest Service of the Department of Agriculture has for many years carried on an extensive program of research in forest products. This program has included a variety of subjects having a direct bearing on the problem of standardization of lumber grades, sizes, and nomenclature. Since the lumber industry became actively interested in the work of promulgating lumber standards, attention has been specifically directed to each of the various phases of this problem.

In this work of the Forest Service, the field of lumber standardization is divided into four divisions: Hardwood lumber, softwood factory lumber, yard lumber, and structural timbers.

A comprehensive survey of the manufacture, distribution, and consumption of both hardwood and softwood factory lumber is now under way. Recommended standard specifications for the grading of yard lumber have been submitted to the Central Committee on Lumber Standards and other interested trade organizations for their consideration. These grading specifications for yard lumber have been published as Department Circular 296.

The fourth division, dealing with structural timbers, is treated in this circular. This phase is one on which the half-million tests made by the Forest Products Laboratory to determine the physical and mechanical properties of wood have a direct bearing. The basic grading rules and working stresses herein proposed are the result of this long series of tests and are submitted to the lumber industry and the consuming public for their earnest consideration.

PURPOSE OF BASIC GRADING RULES.

Tables of working stresses for structural timbers abound in engineering literature and form a part and substance of the building codes of most of our larger cities, but there is an utter lack of unanimity in the values for any given species. At the same time there is an absence of uniform structural timber grading rules, on which the establishment of working stresses is absolutely dependent.

The building codes of the country, with few exceptions, now give a single working stress for a species without any limitation as to grade or quality. When quality is specified, the description of the material is usually general and inadequate, and often the character of material called for is impossible to obtain. Such specifications result in poor construction or poor utilization. When the stress allowed is too high, the timbers are too small to carry the loads for which they are designed, and even when they do not fail completely result in very unsatisfactory structures. When the working stresses are too low for the grade furnished by the local market, the result is a waste of timber and expensive construction.

Decision as to the species of timber to purchase for a definite structural use is now generally based on the reputation of the species for strength, regardless of the grade or defects of the timber, or its specific suitability for the purpose intended. Such a method of selection often fails to insure the use of the most suitable material, for the reason that the defects present may cause a much wider range in strength than the inherent differences in the clear wood of the various species.

As the present commercial grades for structural timbers in general do not specifically limit the defects or cover the inherent quality of species from the strength standpoint, it is impractical to assign correct working stresses to these grades. Nor is it considered practical to establish working stresses by testing various grades of each species as found in the local markets, owing to the vast amount of testing required, the expense involved, and the continually changing character of the material which may be admitted under grades with only general strength limitations.

As a step toward standardization of structural timbers and more efficient utilization, there are presented in this circular a set of grading rules and working stresses for softwood and hardwood timbers. These rules and working stresses are based on the results obtained by the Forest Products Laboratory from hundreds of thousands of tests of small clear specimens, from numerous tests of structural timbers containing defects, and from other intimate studies of the various species involved.[1]

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[1] A complete description of the methods used in making the tests is given in Forest Service Circular 38, "Instructions to Engineers of Timber Tests, Revised." These test methods have also been adopted and published by the American Society for Testing Materials as "Tentative Standards." The results of tests on structural timber of various sizes and species are given in Forest Service Bulletin 108, "Tests of Structural Timbers." Results of tests on small clear specimens are given in U. S. D. A. Bulletin 556, "Mechanical Properties of Woods Grown in the United States."

In substance, the new rules provide for a simple classification of timbers of any species into four basic grades from the standpoint of strength requirements for various structural purposes, excepting columns. The difference in inherent strength and character of various species is taken care of in the recommended working stresses.

The basic rules make no provision for control of the factors which influence durability. Specifications for timbers which are to be subjected to conditions favorable to decay should take these factors into account. Much can be accomplished toward prevention of decay under such circumstances by selecting durable species and permitting only a small percentage of sapwood. In case the lowest basic grade is used under conditions favorable to decay, no infected or decayed material should be permitted, except a very few types of rot which are known not to progress appreciably after the tree is felled. The percentage of sapwood allowed should be definitely stated, with directions as to how it shall be measured. Knot holes, shakes appearing on the surface, and other defects which will collect and hold moisture should also be restricted in timbers which are to be used in wet or damp locations.

The symbols S1 (Structural 1), S2, S3, and S4 for the grades proposed by the Forest Products Laboratory were suggested by the Technical Committee appointed at the Washington Standardization Conference (May, 1922), and these grades have generally been referred to by this nomenclature since that time. Additional names of Select, Standard, and Common were later recommended as grade names by Committee D–7 of the American Society for Testing Materials for the three most important grades, S2, S3, and S4, respectively, which leads to the suggestion of Extra Select for S1, the highest grade.

The Select (S2) grade is especially adapted to heavy construction, such as railway bridge and mill work. The Standard (S3) grade is primarily suitable for general building use and common mill construction. The Common (S4) grade is especially recommended for small-house construction where stiffness is a controlling factor, and where strength requirements are not so critical. These three grades will furnish by far the greater portion of structural timbers used. The Extra Select (S1) is an exceptional grade intended to meet the most exacting strength requirements for construction purposes.

The basic grades were developed primarily upon the size, number, and location of permissible defects, which are limited and classified in a practical way for different parts of a beam in accordance with the economic requirements for different classes of use. The maximum sizes of knots permissible in the four grades bear a simple relation to each other of 1, 2, 3, and 4. Working stresses in the four grades have an equally simple relation, which is dependent upon the size of allowable defects. Differences between light and dense material, in the case of Douglas fir and southern yellow pine, are taken care of by increased working stresses for dense stock.

With specific limitation of defects affecting strength as a fundamental basis for the development of these rules, safe working stresses can be given with assurance. Upon the basic grades can be formulated commercial grades which include provision for such other requirements for particular uses as may be desirable for other than strength purposes.

The proposed basic rules have already been considered by the Central Committee on Lumber Standards, and have been adopted by the Rules Committee of the National Hardwood Lumber Association. Committee D–7 of the American Society for Testing Materials has gone on record as approving the three principal grades—Select (S2), Standard (S3), and Common (S4)—which will be expected to furnish by far the largest part of the structural timbers consumed.

APPLICATION OF BASIC RULES TO COMMERCIAL GRADES.

The regrading of material of a commercial grade in accordance with the basic rules is not difficult of accomplishment. It is only necessary to become familiar with one grade, since, except for the decay permitted in the lowest grade, the difference between grades is in the size of defects, which have the relative sizes 1, 2, 3, and 4. It is this definite relation between size of defects in different grades which makes the basic rules easier to apply than the present commercial rules, in which such a relation does not exist.

The basic rules are a part of the present standardization movement; as yet, material graded in accordance with them can be obtained only on special orders. Until the basic grades are carried by local yards, the consumer can use the basic grading rules to good advantage for the sorting of material of the commercial grades as it is delivered on the job.

Material of all four basic grades is sometimes represented in a single commercial grade. For such a commercial grade design must be based on the weak timbers, and the full strength of the better timbers can not be utilized. For example, inspection of a warehouse revealed that the single commercial grade used contained timbers of sufficiently wide range in quality to represent each of the four proposed basic grades. Approximately two-thirds of the timbers would have qualified, in regrading, as Select (S2) or better. If the building had been redesigned on the basis of the higher working stresses permissible with the Select (S2) grade, the other third of the timbers of lower grade would have been unnecessary, and the redesigned building could have been safely depended upon to carry as great a load as the construction actually used. The strength of the warehouse, therefore, was dependent upon the weak one-third of the timbers, which were scattered promiscuously throughout the structure. This actual case illustrates the possible saving in floor space and construction costs which may be made by using the available material in accordance with its strength.

The advantages of basic grading rules for structural timber have been discussed so far principally from the consumer's viewpoint. There are, however, advantages for the manufacturer in their adoption and use. Wood is being rapidly forced to meet keener and keener competition, because of the fact that architects and engineers can easily obtain steel or other wood substitutes of a known strength. Such material can be obtained by specifying by grade, or otherwise, without the necessity of going into long technical details in specifications. Builders are thus enabled to use wood substitutes economically and safely. This is not true of wood under the present varied commercial systems of grading. An engineer's or architect's professional reputation may be ruined by the failure of one of his structures; and it is evident that he is going to give preference to other materials until the time when wood can be handled with the same ease, safety, and economy as the substitutes.

If wood is to hold its proper place in the structural field, increased latitude of selection, standardization, and widening of the field of available species is necessary. It is the purpose of the basic grading rules to accomplish this result.

FACTORS WHICH AFFECT STRENGTH OF TIMBERS.

The most important factors which influence the strength of structural timbers are the density (or dry weight), the moisture content, and the size, number, and location of defects. These factors must all be considered in design and grading if the maximum utilization is to be obtained from the material used. The proposed basic grading rules control the defects by limiting their size and location in accordance with their effect upon the strength; and working stresses are recommended for each species which take into consideration the allowable defects, the density, and the moisture as determined by conditions of use.

DENSITY.

The density of wood substance of all species is practically the same. The dry weight is, therefore, a measure of the amount of wood substance present; and on the amount of wood substance present depends the strength of clear wood. In some species the density may be estimated by the proportion of summer wood present, summer wood in softwoods being the heavy dark portion of the annual growth layers. The percentage of this heavy, dark wood present furnishes a practical means of grading for strength southern yellow pine and Douglas fir, two of the most important species used as structural timbers. Timbers from these species are divided into three classes, designated as Dense, Medium, and Exceptionally Light. The division is made by a visual inspection of the end grain, a method devised by the Forest Service and adopted by the American Society for Testing Materials.[2] Southern yellow pine timbers which have not been graded for density are classified by the American Society for Testing Materials as Sound, and in this circular as Medium. Exceptionally light pieces, however, are excluded from the medium class.

All other species have only two classes—Medium and Exceptionally Light. This is because of the fact that as yet no quick, easy, and fairly accurate method has been devised for determining their density.

MOISTURE.

Moisture affects the strength of structural timbers both directly and indirectly. The direct effect of loss of moisture is the stiffening and strengthening of the wood fibers. This increase in strength, however, is accompanied by checking, splitting, warping, and twisting; as a consequence, some of the strength due to drying is lost. Because of this loss, and because of the fact that most structural timbers are liable to be wet during some period of their life, it is impractical to utilize the full increase in strength due to drying.

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[2] The definitions for the Dense class of southern yellow pine and Douglas fir, as adopted by the American Society for Testing Materials, are given in the appendix of this circular.

Timbers in damp or wet locations usually decay to some extent before removal. Some allowance for this weakening has been made in the stresses recommended. Table 1 provides for each species three basic working stresses suited to the moisture condition under which timbers are to be used. The conditions are designated as Wet or Damp, Dry Outside, and Dry Inside.

The stresses given in Table 1 under the Wet or Damp heading are for use in docks, piling, sills, and timbers similarly located. Stresses for timbers used in such structures as bridges and open sheds, where they will have good air circulation around them, are given under the heading Dry Outside. Such timbers will be air-dry but subject to occasional wetting. The highest stresses are given for the timbers which are to be used in dry locations, such as interior house, factory, and warehouse construction. Under these last-named conditions, the wood will frequently drop to even lower moisture content than can be obtained in air drying, and will seldom, if ever, go above the moisture content of air-dry wood.

DEFECTS.

Defects are any irregularities occuring in or on wood that may lower some of its strength properties. The strength of wood is dependent more upon the size, number, and location of defects than upon the species or density. Defects are divided into two groups: (1) Those which materially affect the strength and must be considered in strength rules, and (2) those which would normally be excluded for other reasons than their effect on strength in extreme fiber and strength in shear. The first group includes knots, decay, shakes, checks, splits, and cross grain; and the grading rules definitely limit the size allowable in each grade.

Group 1. DEFECTS LIMITED BY STRENGTH RULES.

KNOTS AND KNOT HOLES.

On the basis of effect on strength, the various kinds of knot defects are classified into three groups—sound knots and knot holes, unsound knots, and cluster knots. No distinction is made between knots and knot holes, for observation in recent tests has shown that intergrown knots are fully as injurious to the strength as knot holes or incased knots of the same size. This is because of the greater distortion of the grain which occurs around the intergrown knots.

The effect on strength of the shape of a knot, such as round, oval, spike, or branch, has been taken care of in the method prescribed in the rules for measuring the knots. Cluster knots, which consist of two or more knots grouped together as a unit with the fibers of the wood deflected around the entire unit, are prohibited, except in the lowest grade, because their diameter is not a good indication of the effect they may have on the strength.

DECAY.

Decay is disintegration of the wood substance due to the action of certain kinds of fungi. Decay is prohibited in all except the lowest grade, because once started it may continue under certain conditions after the timber enters the structure and because there is no satisfactory method of determining the extent to which a timber is affected.

A decayed knot is softer than the surrounding wood and contains advanced decay. Knots which contain decay to a depth in excess of the diameter of the knot are prohibited in all but the lowest grade, because decay which enters the bole of a tree by way of a knot usually seriously injures the strength of timber cut from it without any indication appearing on the surface. Decay in a knot usually shows further advance with depth and where such is the case is a very serious menace to the strength. Decay in knots which does not extend deeply into the bole becomes less pronounced with depth in the knot. Such decayed knots have no worse effect on the strength than sound knots of the same size.

SHAKES.

A shake is a separation of the wood, the greater part of which occurs between the growth rings. Shakes occur only as the result of a weakness of bond between the growth rings. In structural timbers the only safe method is to assume that the shakes which appear on the end extend to the center of length, as there is usually a weakness in the bond between these individual rings which extends far beyond the point of actual separation of the rings.

Shakes reduce the area acting in resistance to shear, and the limitations placed on shakes are therefore based on this reduction. Whether a shake appears on a face or is boxed does not influence the shear area affected and therefore is not important from a strength standpoint. Shakes appearing on the surface are permitted, but where any special use to which a timber is to be put is such as to make shakes appearing on the surface undesirable, they should be excluded on that basis.

CHECKS.

A check is a lengthwise separation of the wood, the greater part of which occurs across the growth ring. Checks are prohibited on the same basis as shakes, which is the reduction in the shear area. Checks occurring on the narrow or horizontal face have practically no effect upon the strength of straight-grained stock, whereas checks occurring on the wide or vertical face are most serious when straight and at the center of the height, and their effect depends upon the area of the longitudinal section they cover.

SPLITS.

Splits are lengthwise separations of the wood due to tearing apart of the wood cells. They should be classified as checks or shakes and graded as such.

CROSS GRAIN.

Cross-grained wood is that in which the wood cells or fibers do not run parallel with the axis of a piece. The limits placed on cross grain are based on the results of a detailed study of the effect of cross grain and spiral grain upon the strength, and the weakening of material by checks which invariably develop and which, without exception, follow the grain.

Group 2. DEFECTS NOT LIMITED BY STRENGTH RULES.

Such defects as pitch pockets, pitch, wane, worm holes, warp, pith, and imperfect manufacture are not mentioned in the rules. They injure the appearance and unfit the material for some uses. The extent to which they are permissible in structural timbers is limited by considerations other than strength. These considerations limit them to an extent that makes their influence on the strength unimportant. A discussion of these defects follows:

PITCH POCKETS.

A pitch pocket is a well-defined opening between annual layers of growth, usually containing more or less pitch, either solid or liquid. A pitch pocket is, therefore, a local shake filled with pitch. It usually does not have sufficient length to cause failure by shear. A large number of pitch pockets in a timber indicates the presence of general shakes, and such timbers should be carefully inspected.

PITCH.

Pitch is a poorly defined accumulation of resin in the wood cells in a more or less regular patch. It has no serious effect upon the strength, however, a timber in which the whole end is saturated with pitch is to be regarded with suspicion, as such timbers have proved to be somewhat erratic under test.

Pitch may be a serious defect for some uses; for example, painted timbers which are heavy with pitch when placed in the sun or warm location exude resin and spoil the finish.

WANE.

Wane is bark or lack of wood from any cause on the edge or corner of a piece. Wane is limited by such considerations as bearing area, nailing edge, appearance, fire hazard, etc.; and any limitation for these reasons is sufficient to insure material which is not weakened to a greater extent than will result from the allowable knots. However, when wane occurs at or near a maximum allowable knot, the combined effect of the two defects should be considered by the grader.

INSECT HOLES.

Holes are enumerated as knot, dog, picaroon, bird, insect (including pin, shot, grub worm, etc.), and rafting-pin holes, through pitch pockets, and the like. The effect of insect holes is very similar to that of knot holes, except that there is no grain distortion around insect holes. Insect holes have only small diameters, usually less than one-half inch. It is evident, therefore, that the application of knot-hole limitations to insect holes will cause the rejection of timbers only when the attack has been very severe. The diameters of the insect holes should be limited for each grade as are the diameters of knots. This will seldom cause the rejection of timbers because of insect holes, but in some species timbers are subject to such severe attacks that their rejection is advisable.

PITH.

Pith is the small, soft core in the growth center of a log. Checks and shakes quite commonly occur near the pith and spoil the timber for finishing purposes. These should be graded as any other checks or shakes, as their effect on strength is the same.

WARPING.

Warping is any variation from the true plane surface. It includes crook, bow, cup, twist, or any combination of these. These defects are largely the results of seasoning, and to a very great extent may be avoided by proper piling and weighting. Cross-grained timbers usually warp more than straight-grained ones, and a badly warped timber should be closely examined for cross grain. Except for the indication it gives of the presence of cross grain, warping is not important from a strength standpoint, especially in large timbers. In small timbers it increases the work of placing the timber in the structure, and it should be limited by these considerations rather than considerations of strength.

IMPERFECT MANUFACTURE.

Imperfect manufacture includes all defects or blemishes which are produced in the manufacturing process. Undersized and nonuniform width or thickness are included under this head. Ordinary variation in size, when local, will not weaken a timber or lower its stiffness as much as the other allowable defects. Variations in size are not of importance from the standpoint of strength as a beam or post, unless they are combined with a defect of or near the maximum allowable limit. Timbers should have their strength calculated from their actual size and not on some nominal figure. Provision is thus made for timbers which are uniformly under size.

EFFECT OF DEFECTS ON STRENGTH.

The allowable working stress for any grade of timber must take into consideration the loss of strength which results from the defects permitted in the grade. Thus, when a knot of a diameter equal to one-fourth the width of the face on which it occurs, is allowed at the point of maximum stress, the timber is assumed to be only three-fourths as strong as one of clear material of the same quality. The number of defects is controlled by specifying the total sum allowable in terms of the dimensions of the beam. This provision also controls the quality of the material to some extent, since timbers with a large number of knots are usually from the tops of trees and are inherently weaker than those from the lower or butt cuts.

STRUCTURAL TIMBER GRADES.

NAMES OF GRADES.

It is believed that the various uses of structural timber can be satisfactorily covered by four basic grades. The proper naming of these grades is very difficult on account of the significance attached to various names and symbols by commercial practice. The original names proposed by the Forest Service were Extra Select, Select, Grade No. 1, Grade No. 2. The Technical Committee on Standardization of Lumber of the General Standardization Committee designated these grades as S1, S2, S3, and S4. Committee D–7 (on timber) of the American Society for Testing Materials questioned the advisability of using the S1, S2, S3, and S4 designations on the grounds that they would be confused with such abbreviations as that for surface one side (S1S), and because poor utilization would result from the tendency of many consumers to specify No. 1 regardless of the use. Committee D–7 (on timber) at one time recommended that the grade names be indicative of their purpose or most prominent use, and later recommended that the S2, S3, and S4 grades be called Select, Standard and Common, respectively, and that the S1 grade be omitted.

The Rules Committee of the National Hardwood Lumber Association has adopted the designations S1, S2, S3, and S4 for basic grades. In the commercial rules to be drawn from these grades other names will be used, but reference will be made to the basic grade—for example, No. 1 Dimension (S3). The names by which the Forest Service will eventually designate the four basic grades have not been definitely determined. Regardless of the names finally given the basic grades, however, all commercial grades should have names that will make it possible to recognize the grade on which they are based.

In this circular both the terms Select, Standard, Common, and Extra Select, and the corresponding designations S2, S3, S4, and S1 are used. It is hoped that this double designation will bring sufficient comments to insure the selection of the most useful names. This double system of names is necessary in order to tie up the data already published with the recent changes.

USES OF GRADES.

Each of the four grades is especially suitable for certain classes of construction. No better grade of material should be selected than will meet the requirements of the work, since use of high grades where low grades will serve satisfactorily is wasteful. The general use of the grades is as follows:

Extra Select (S1)	For use where highest strength requirements obtain in exceptional places in railway and mill construction.
Select (S2)	For general use in railway and mill construction, and whenever a select grade of structural material is desirable.
Standard (S3)	For general use in building construction, and to a large extent in mill construction.
Common (S4)	For general use in small houses, false work, and ordinary construction where strength requirements are not so critical.

Select (S2) is the base grade and is expected to furnish most of the timbers used in heavy construction work where high breaking strength is desired. The Extra Select (S1) grade is expected to furnish timbers to be used when the requirements are exceptional, such as in extra long bridge-spans or under heavily loaded floors in mill construction where cross-section dimensions are limited. The Select (S2) grade can be cut in sufficient quantities to supply all the heavy construction timbers which the trade will use. On the other hand, Extra Select (S1) will be difficult to obtain in some species, and will probably be obtainable in any species only on special orders and at a comparatively high price. The Extra Select (S1) grade is, therefore, the least important of any of the grades and is only included so that the basic defect limitation for strength will be available when exceptional conditions or uses require unusually high unit strength values.

The use of the Standard (S3) and Common (S4) grades in small house construction is very desirable. Where the rot permitted in the Common grade will cause further deterioration, this defect should be eliminated from the grade. These grades are suitable where stiffness is the controlling factor. For such use, timbers large enough to give the required stiffness will have sufficient breaking strength, even though they contain comparatively large defects. Their use in small house construction offers advantages to sawmill operator, consumer, and distributor. The sawmill operator, especially the small one, can manufacture top logs into these grades and dispose on the local market of material which otherwise quite often would be left in the woods, because it can not compete with other material when transportation charges are added. As the stiffness of low grades is only slightly less than that of high grades, the consumer can obtain a material suitable for his purpose at a low cost. The low selling price will materially aid the manufacturer and distributor in their competition with wood substitutes.

BASES OF DEFECT LIMITATIONS.

In formulating the strength grades, the Select (S2) grade has been taken as the standard or base. This grade corresponds very closely to Grade 1 of Forest Service Bulletin 108, to the Select Structural grade of the Southern Pine Association, and to No. 1 Structural of the West Coast Lumbermen's Association.

The allowable defects and working stresses were established for the Select (S2) grade from the results of strength tests, and the factors controlling the strength of the other grades bear a definite relation to those of the base.

Considering Select (S2) as the base grade, knots in the Extra Select (S1) are limited to 1/2 the size of those in the Select (S2), in the Standard (S3) to 3/2 those of the Select (S2), and in the Common (S4) to 4/2 of those of the Select (S2). The sizes of defects permitted in the four grades therefore bear the simple relation of 1, 2, 3, and 4, except for shake in seasoned timbers, in which case the relation of 2, 3, 4, and 5 exists.

The base grade allows defects which reduce the strength to 6/8 that of clear material, or results in a strength loss of 2/8. The Standard (S3) grade, with defects 1–1/2 times as large as Select (S2), causes a loss in strength 1–1/2 times that of Select (S2), or 3/8. Hence the Standard (S3) grade will have 5/8 the strength of clear material. The stresses for the other grades may be determined in like manner. Thus, for the four grades the stresses will be seen to bear the relation 7/8, 6/8, 5/8, and 4/8, or 7, 6, 5, and 4. The stress for any one grade being given, that for any other grade may be computed from these ratios.

WORKING STRESSES.

DETERMINATION OF BASIC STRESSES.

Safe working stresses for timber are derived both from tests of small clear specimens which afford average values of the inherent strength of the different species, and from tests of large timbers which establish the influence of defects. The determination of a safe working stress then involves the adjustment of test values to meet the conditions of use. This adjustment requires (*a*) consideration of the loss in strength from defects, (*b*) the effect of long-continued loads, (*c*) the variability of individual pieces from the average, and (*d*) the possibility of slight accidental overloading.

The effect of each of these factors [3] is to necessitate a lower strength value for practical use conditions than is obtained from average test results of small clear specimens. Their combined effect may be embodied in a single factor, usually called a "factor of safety," which can be applied to average results of strength tests on small clear specimens to obtain safe working stresses. It is evident that the larger part of this so-called "factor of safety" is required to correlate laboratory test results with actual conditions of use, and only a small part of this factor may be considered a true factor of safety.

The belief that a timber with a so-called "factor of safety" of 3 or 4 will carry three or four times the load for which it is designed is erroneous and has caused many failures through overloading of structures. The application of a load which would produce three times the working stresses given in this circular would be expected to cause the immediate failure of some of the timbers, and the ultimate failure of 75 per cent of them. The application of loads which would produce stresses only one and one-half times the working stresses would be expected to cause occasional failures if the loads were left on for any great length of time.

STRESSES FOR ALL GRADES.

The working stresses for use with the base or Select (S2) grade are given in Table 1 for the most important species used in structural timber. All the factors except defects which enter into the determination of these basic stresses are the same for all grades of a species, and having been considered in determining the working stress for the base grade do not need to be considered further in determining stresses for other grades. The stresses for the grades have been shown to bear the relation of 7 to 6, 5, and 4. If the base stress is taken as 1 or 6/6, the stresses for the other grades will be for Extra Select (S1) 7/6, Standard (S3) 5/6, and Common (S4) 4/6 of the stress for the base grade. Thus, the difference between the working stresses of consecutive grades is 1/6 of the working stress of the base grade.

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[3] The following summary of each factor may be of especial value: (*a*) From the previous discussion it is evident that when defects are definitely limited as in each of the proposed grades their effect can be readily determined; (*b*) other tests have shown that long-continued loads on beams will ultimately produce failure at about one-half to three-fourths the load obtained under standard test conditions; (*c*) because of the variation in the strength of timber, individual pieces may have approximately only one-half to three-fourths the strength of the average for the species; (*d*) while structures should not be subjected to loads in excess of those for which they are designed, some provision should nevertheless be made for slight accidental overloads.

The working stresses for Douglas fir and southern yellow pine timbers of any grade which meet the density requirements of the American Society for Testing Materials are increased one-sixth of the stress allowed for the base or Select (S2) grade. Stresses for pieces of exceptionally light weight in any species should be reduced one-sixth of the stress allowed in the base grade. Thus there are three stresses for each grade of southern yellow pine and Douglas fir—one for dense, one for medium, and one for light-weight material. These triple stresses do not increase the number of basic grades, of which there are only four. The Extra Select (S1) Dense is not a fifth grade; it is a certain quality of material in the Extra Select (S1) grade.

In practice, Extra Select (S1) will in all probability be a special grade cut only on order, or selected for use in special places from material delivered on the job.

Figure 1 is a graph for determining the working stress for any grade when the stress for the Select (S2) grade is known. The correct working stress for dense material can also be obtained from the graph, as dense material takes the working stress of the next higher grade. A separate line is given for determining the working stress of dense material of Extra Select (S1) grade. To determine the stress for any grade from the graph, the basic stress for Select (S2) grade is taken from Table 1. The number corresponding to this stress in units of 10, 100, and 1,000 pounds per square inch is located on the horizontal scale. The vertical line through this number is followed to its intersection with the line representing the grade desired. A horizontal line through this intersection point will read the proper stress for the desired grade in the same units as were taken on horizontal scale.

Example.—To determine the working stress in bending for Douglas fir or southern yellow pine for Common (S4) grade for use in dry locations.

The working stress for Select (S2) grade as taken from Table 1 is 1,500 pounds per square inch.

The vertical line through 15 of the horizontal scale intersects the sloping line representing the Common (S4) grade opposite 10 on the vertical scale. The working stress for Common (S4) grade is, therefore, 10 hundred, or 1,000, pounds per square inch. If the Common (S4) material meets the density requirements, it takes the stress of the Standard (S3) grade. The vertical line through 15 intersects Standard (S3) at 12½; therefore, the working stress for dense material of Common (S4) grade is 12½ hundred, or 1,250, pounds per square inch.

BASIC GRADING RULES RECOMMENDED FOR SOFTWOOD AND HARDWOOD STRUCTURAL TIMBERS.

PURPOSE AND SCOPE OF RULES.

The grading rules presented here propose basic grades for structural timbers of all species. The limitations of defects apply to all species. The quality of material, or inherent differences in species, is taken care of in the recommended working stresses.

Only factors which affect the strength have been considered in the compilation of these grades. Special and specific use will require supplemental specifications, depending on other factors, such as durability, finish, etc.

These rules, of course, should not be applied to large timbers which are to be remanufactured. When such material is recut into structural sizes, the rules should be applied after remanufacture.

Beams, girders, and joists usually have one cross-sectional dimension larger than the other and are set on edge. Knots on the upper edge or face are not so injurious to the strength as those on the lower face. Because of the likelihood of either side of a beam being placed up, however, it is usually necessary to limit defects on both narrow faces in the same manner. A beam which shows on the two edges a difference of one or more grades may safely take the stress of a grade one higher than the grade of the poorer edge, provided the beam is placed with the better edge down.

Square timbers are not usually an economical form for beams and should seldom be used for this purpose. The grading rules when applied to square timbers shall limit the defects on all faces as prescribed for the narrow face, except when the timber is to be used as a post or column, in which case these rules do not apply.

GENERAL SPECIFICATIONS.

Structural timbers shall be divided into four grades, namely, Select (S2), Standard (S3), Common (S4), and Extra Select (S1). The restrictions for the Select (S2) grade are given first, since this is taken as the base grade.

LIGHT WEIGHT.

All exceptionally light-weight pieces in any species shall be lowered one grade.

DENSE.

Southern yellow pine and Douglas fir which will classify as dense under the rules of the American Society for Testing Materials for these species take the stress of the next higher grade.

KNOTS AND KNOT HOLES.

The measurement of knots or knot holes is made on the section of the knot or knot hole appearing on the surface in question. The diameter of a knot on the narrow or horizontal face shall be taken as the width of the knot between lines parallel to the edges of the timber. On the wide or vertical face the smallest dimension of a knot shall be taken. Knots on the edge of wide faces are limited to the same size as on the adjacent portion of the narrow faces. Cluster knots occurring on any face in any part of a beam shall cause its rejection except when specifically permitted. The diameter of cluster knots shall be measured between lines inclosing the cluster.

Unsound or decayed knots in which the decay is not in excess of the diameter of the knots are limited as are sound knots.

CHECKS, SHAKES, AND SPLITS.

Checks, or combination of checks with shakes, which would reduce the strength to a greater extent than the allowable round shake shall not be permitted. Restrictions on shakes are given in each grade.

The width of shakes shall be taken as the distance between lines parallel to the vertical edges of a timber. Splits shall be graded as checks or shakes.

DECAY.

All grades shall contain only sound wood unless decay is specifically permitted.

SAPWOOD.

Unless otherwise specified any amount of sapwood is admitted in all grades.

HOLES.

Dog, picaroon, bird, insect, and rafting-pin holes shall be limited for each grade in the same manner as knot holes.

OTHER DEFECTS.

Defects other than knots, knot holes, decay, shakes, checks, splits, and cross grain are omitted from these rules, as they are limited ordinarily by considerations other than strength and should be restricted when necessity requires by application of standard yard lumber rules to faces.

METHOD OF MEASURING DEFECTS.

Figure 2 illustrates the method of measuring the various kinds of knots on the horizontal and vertical faces, and the method of measuring shakes on the ends. The gradual increase in size of the allowable knots from the center one-third of length to end and from edge to center of the wide face is also illustrated. The table accompanying the figure gives in condensed form the defect limitations of all grades.

SELECT (S2) (BASE GRADE).

KNOTS.

General.—The sum of the diameters of all knots within the center half of the length of a beam shall not exceed the width of the face on which they occur.

Narrow or horizontal faces.—A knot hole or sound knot on the narrow or horizontal faces and in the center third of the length of a beam shall not exceed in diameter one-fourth the width of the face (maximum knot 1½ inches). Outside the center one-third of the length, the size of a knot may increase gradually toward the end to half the width of the face (maximum knot 3 inches).

Wide or vertical faces.—Knot holes or sound knots on the edges of the wide faces shall be limited to the same size as on the adjacent portion of the narrow faces, but a knot may increase gradually in size toward the center of height to one-fourth the width of the face (maximum knot 3 inches).

SHAKES.

Round or ring shakes showing on the end of a timber shall not measure more than one-fourth of the width in green material nor more than one-third of the width in seasoned material.

CROSS GRAIN.

Within the center half of the length of a beam the slope in grain shall not exceed 1 in 15.

EXTRA SELECT (S1).

KNOTS.

General.—The sum of the diameters of all knots within the center half of the length of a beam shall not exceed half the width of the face on which they occur.

Narrow or horizontal faces.—A knot hole or sound knot on the narrow or horizontal faces and in the center third of the length of a beam shall not exceed in diameter one-eighth the width of the face (maximum knot ¾ inch). Outside the center one-third of the length, the size of a knot may increase gradually toward the end to one-fourth the width of the face (maximum knot 1½ inches).

Wide or vertical faces.—Knot holes or sound knots on the edge of the wide faces shall be limited to the same size as on the adjacent portion of the narrow faces, but a knot may increase gradually in size toward the center of height to one-eighth the width of the face (maximum knot 1½ inches).

SHAKES.

Round or ring shakes showing on the end of a timber shall not measure more than one-eighth of the width in green material nor more than two-ninths of the width in seasoned material.

CROSS GRAIN.

Within the center half of the length of a beam the slope in grain shall not exceed 1 in 20.

STANDARD (S3).

KNOTS.

General.—The sum of the diameters of all knots within the center half of the length of a beam shall not exceed one and one-half times the width of the face on which they occur.

Narrow or horizontal faces.—A knot hole or sound knot on the narrow or horizontal faces and in the center third of the length of a beam shall not exceed in diameter three-eighths the width of the face (maximum knot 2¼ inches). Outside the center one-third of the length, the size of a knot may increase gradually toward the end to three-fourths the width of the face (maximum knot 4½ inches).

Wide or vertical faces.—Knot holes or sound knots on the edge of the wide face shall be limited to the same size as on the adjacent portion of the narrow face, but the knot may increase gradually in size toward the center of height to three-eighths the width of the face (maximum knot 4½ inches).

SHAKES.

Round or ring shakes showing on the end of a timber shall not measure more than three-eighths the width in green material nor more than four-ninths the width in seasoned material.

CROSS GRAIN.

Within the center half of the length of a beam the slope in grain shall not exceed 1 in 11.

COMMON (S4).

DECAY.

A beam may contain heart rot not to exceed one-tenth the area of the cross section of the piece.

KNOTS.

General.—The sum of the diameters of all knots within the center half of the length of a beam shall not exceed twice the width of the face on which they occur. Unsound or decayed knots to half the size of the sound knots are permitted in this grade. Cluster knots of the same diameter as sound knots are permitted in this grade.

Narrow or horizontal faces.—A knot hole or sound knot on the narrow or horizontal faces and in the center third of the length of a beam shall not exceed in diameter half the width of the face (maximum knot 3 inches). Outside the center one-third of the length, the size of knot may increase gradually toward the end where it may be equal to the width of the face (maximum knot 6 inches).

Wide or vertical faces.—Knot holes or sound knots on the edges of the wide faces shall be limited to the same size as on the adjacent portion of the narrow face, but the knot may increase gradually in size toward the center of the height to half the width of the face (maximum knot 6 inches).

SHAKES.

Round or ring shakes showing on the end of a timber shall not measure more than half the width in green material nor more than five-ninths the width in seasoned material.

CROSS GRAIN.

Within the center half of the length of a beam the slope in grain shall not exceed 1 in 8.

APPENDIX.

CARE OF TIMBERS.

The care which untreated timber receives after it is delivered on the job is an important factor in determining the strength of the completed structure. The most common abuses are the improper piling of material and failure to protect it from rain and sunshine. Green, wet, or partially dry timber when close-piled or piled without provision being made for good circulation of air will soon be infected with decay, especially in warm, damp weather. Decay once started quite often continues after the timber is placed in the structure and results in a serious loss of strength.

The best method of obtaining durability is by specifying a good preservative treatment. The selection of timbers by species without consideration of the possibilities of preservative treatment often results in shipping timber long distances when more suitable material is available locally. The less durable species when treated with preservatives usually last much longer than the untreated durable species.

Poor piling and exposure to sunshine and rain with ensuing wetting and drying are often disastrous and increase the difficulties of construction and cost. Through the development of checks, shakes, warping, twisting, and cupping, material which is of the highest grade when received may practically fall to pieces between the rings under such treatment. Timbers will shrink if they have not been properly seasoned before placing in the structure. This shrinkage may cause considerable trouble, due to opening up of joints and cracks, and result in unequal settling.

DEFINITION FOR SOUTHERN YELLOW PINE.[1]

Southern yellow pine.—This term includes the species of yellow pine growing in the Southern States from Virginia to Texas; that is, the pines hitherto known as longleaf pine (*Pinus palustris*), shortleaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), slash pine (*Pinus caribaea*), and pond pine (*Pinus serotina*).

Under this heading two classes of timber are designated: (A) Dense southern yellow pine and (B) sound southern yellow pine. It is understood that these two terms are descriptive of quality rather than of botanical species.

(A) Dense southern yellow pine shall show on one end or the other an average of at least six annual rings per inch and at least one-third summer wood, or else the greater number of rings shall show at least one-third summer wood, all as measured over the third, fourth, and fifth inches of a radial line from the pith. Wide-ringed material excluded by this rule will be acceptable, provided that the amount of summer wood as above measured shall be at least one-half.

The contrast in color between summer wood and spring wood shall be sharp and the summer wood shall be dark in color, except in pieces having considerably above the minimum requirement for summer wood.

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[1] Devised by the Forest Service and adopted by the American Society for Testing Materials.

In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the same inspection shall be made over 3 inches on any approximate radial line beginning at the edge nearest the pith in timbers over 3 inches in thickness and on the second inch (on the piece) nearest to the pith in timbers 3 inches or less in thickness.

In dimension material containing the pith but not a 5-inch radial line, which is less than 2 by 8 inches in section or less than 8 inches in width that does not show over 16 square inches on the cross section, the inspection shall apply to the second inch from the pith. In larger material that does not show a 5-inch radial line the inspection shall apply to the 3 inches farthest from the pith.

The radial line chosen shall be representative. In case of disagreement between purchaser and seller the average summer wood and number of rings shall be the average of the two radial lines chosen.

(B) Sound southern yellow pine shall include pieces of southern pine without any ring or summer wood requirements.

DEFINITIONS FOR DENSE DOUGLAS FIR.[2]

I. DEFINITIONS.

The following definitions are used in connection with these specifications:

(*a*) *Annual ring.*—Each annual ring is composed of two distinct types of wood structure, namely, the porous, light-colored and light-weight spring wood formed during the first part of the growing season and the hard, dense, and darker-colored summer wood formed during the latter part of the growing season.

(*b*) *Summer wood.*—Summer wood is the hard, dense portion of the annual ring. It is darker in color than the more porous spring wood.

(*c*) *Dense Douglas fir.*—This term is applied to a class of material selected with reference to the density of its wood substance content. It shall be understood that this term is descriptive of the quality of the clear wood.

II. PHYSICAL PROPERTIES.

Dense Douglas fir shall show on one end or the other an average of at least six annual rings per inch and at least one-third summer wood measured over 3 inches on a line located as described hereinafter. Rapid-growth material, excluded by this rule, shall be acceptable, provided that the amount of summer wood measured as described shall be at least one-half. Material in which the proportion of summer wood is not clearly discernible shall not be accepted.

Any timber whose least dimension is less than 5 inches shall not show the pith on the inspection end; pieces whose least dimension is 5 inches or more may contain the pith.

(*a*) *Pith present.*—When the least dimension is 5 inches or more, the pith being persent, the line over which the rate of growth and percentage of summer-wood measurements shall be made, shall run from the pith to the corner farthest from the pith. The 3-inch line shall begin at a distance from the pith equal to 2 inches less than one-half the least dimension of the piece.

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[2] Devised by the Forest Service and adopted by the American Society for Testing Materials.

When the rings are very irregular it may be necessary to shift the line somewhat around the piece to get a fair average for inspection, but the distance from the pith to the beginning of the 3-inch line must not be changed.

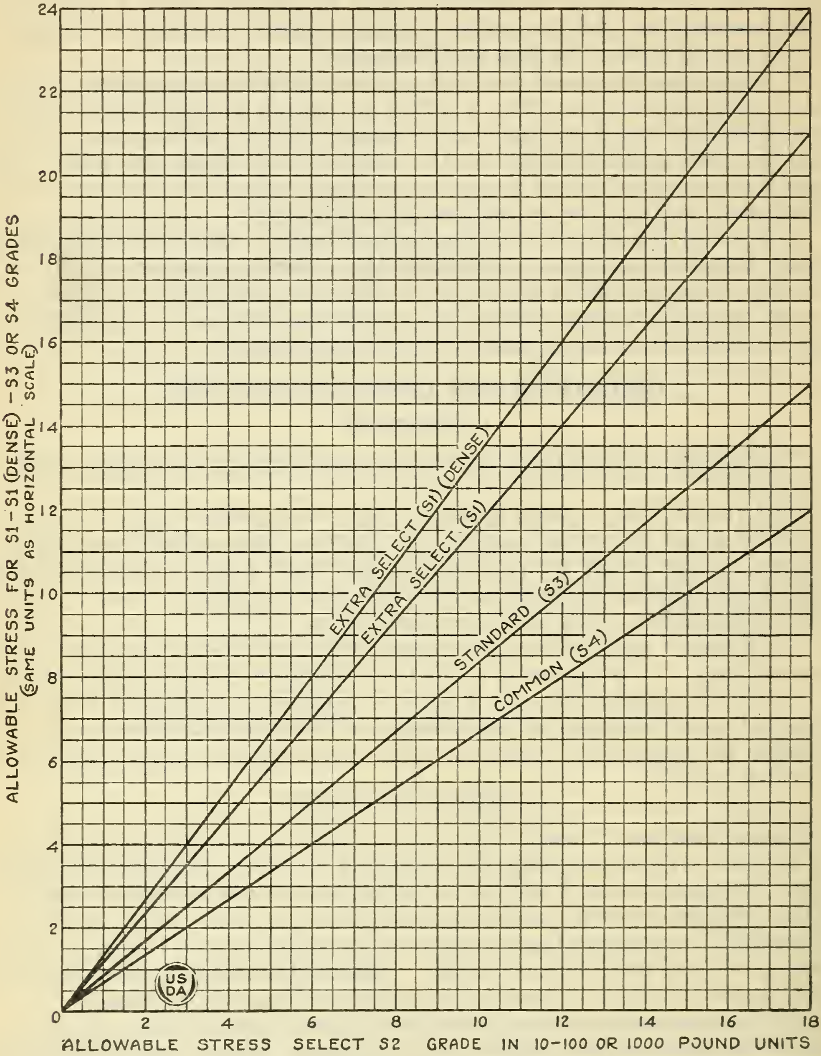
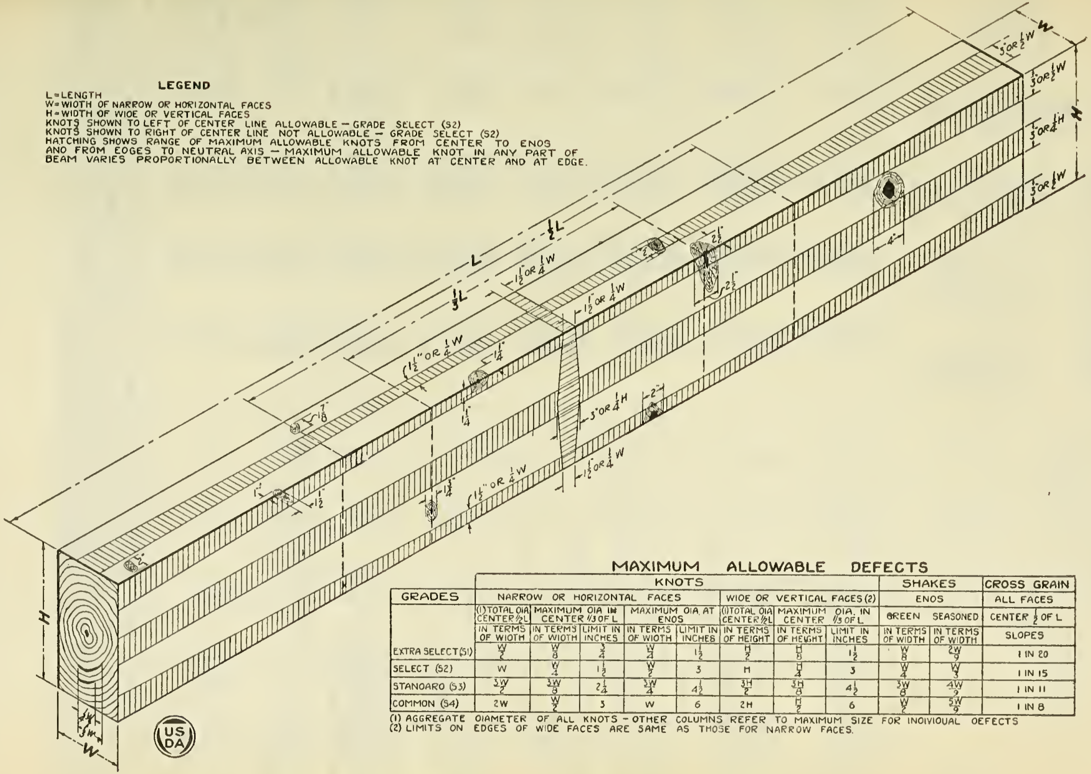


FIG. 1.—Graph for determining the working stress for any grade when the stress for the standard or S2 grade is known.

(*b*) *Pith not present.*—For all pieces where the pith is not present the center of the 3-inch line shall be at the center of the end of the piece, and the direction of the 3-inch line shall be at a right angle to the annual rings.

(*c*) If a radial line of 3 inches can not be obtained, the measurement shall be made over the entire radial line that is available.



LEGEND

L = LENGTH
W = WIDTH OF NARROW OR HORIZONTAL FACES
H = WIDTH OF WIDE OR VERTICAL FACES
KNOTS SHOWN TO LEFT OF CENTER LINE ALLOWABLE — GRADE SELECT (S2)
KNOTS SHOWN TO RIGHT OF CENTER LINE NOT ALLOWABLE — GRADE SELECT (S2)
HATCHING SHOWS RANGE OF MAXIMUM ALLOWABLE KNOTS FROM CENTER TO ENDS AND FROM EDGES TO NEUTRAL AXIS — MAXIMUM ALLOWABLE KNOT IN ANY PART OF BEAM VARIES PROPORTIONALLY BETWEEN ALLOWABLE KNOT AT CENTER AND AT EDGE.

MAXIMUM ALLOWABLE DEFECTS

GRADES	KNOTS								SHAKES		CROSS GRAIN
	NARROW OR HORIZONTAL FACES					WIDE OR VERTICAL FACES (2)			ENDS		ALL FACES
	(1) TOTAL DIA. CENTER ½ L	MAXIMUM DIA. IN CENTER ⅓ OF L		MAXIMUM DIA. AT ENDS		(1) TOTAL DIA. CENTER ½ L	MAXIMUM DIA. IN CENTER ⅓ OF L		GREEN	SEASONED	CENTER ½ OF L
	IN TERMS OF WIDTH	IN TERMS OF WIDTH	LIMIT IN INCHES	IN TERMS OF WIDTH	LIMIT IN INCHES	IN TERMS OF HEIGHT	IN TERMS OF HEIGHT	LIMIT IN INCHES	IN TERMS OF WIDTH	IN TERMS OF WIDTH	SLOPES
EXTRA SELECT (S1)	$\frac{W}{2}$	$\frac{W}{8}$	$\frac{3}{4}$	$\frac{W}{4}$	$1\frac{1}{2}$	$\frac{H}{2}$	$\frac{H}{8}$	$1\frac{1}{2}$	$\frac{W}{8}$	$\frac{2W}{9}$	1 IN 20
SELECT (S2)	W	$\frac{W}{4}$	$1\frac{1}{2}$	$\frac{W}{2}$	3	H	$\frac{H}{4}$	3	$\frac{W}{4}$	$\frac{W}{3}$	1 IN 15
STANDARD (S3)	$\frac{3W}{2}$	$\frac{3W}{8}$	$2\frac{1}{4}$	$\frac{3W}{4}$	$4\frac{1}{2}$	$\frac{3H}{2}$	$\frac{3H}{8}$	$4\frac{1}{2}$	$\frac{3W}{8}$	$\frac{4W}{9}$	1 IN 11
COMMON (S4)	2W	$\frac{W}{2}$	3	W	6	2H	$\frac{H}{2}$	6	$\frac{W}{2}$	$\frac{5W}{9}$	1 IN 8

(1) AGGREGATE DIAMETER OF ALL KNOTS — OTHER COLUMNS REFER TO MAXIMUM SIZE FOR INDIVIDUAL DEFECTS
(2) LIMITS ON EDGES OF WIDE FACES ARE SAME AS THOSE FOR NARROW FACES.

FIG. 2.—Application of basic grading rules to a structural timber.

TABLE 1.—*Working stresses permissible for structural timbers of select (S2) grade.*[1]

[Pounds per square inch.]

Species.	Bending.				
	Allowable stress in extreme fiber for Select (S2) grade.			Allowable horizontal shear stress Select (S2) grade—all locations.	Allowable modulus of elasticity for all grades—all locations.
	Damp or wet location (docks, piling, and sills).	Outside, not in contact with soil (bridges and open sheds).	Under shelter in dry location (factories and warehouses).		
Ash, black	800	900	1,000	90	1,100,000
Ash, commercial white (green, biltmore, white)	1,000	1,200	1,400	125	1,500,000
Aspen and large-tooth aspen	500	650	800	80	900,000
Basswood	500	650	800	80	900,000
Beech	1,000	1,300	1,500	125	1,600,000
Birch, paper	600	750	900	80	1,000,000
Birch, yellow and sweet	1,000	1,300	1,500	120	1,600,000
Cedar, Alaska	800	900	1,000	90	1,100,000
Cedar, western red	750	800	900	80	1,000,000
Cedar, northern and southern white	600	650	750	70	800,000
Cedar, Port Orford	900	1,000	1,100	100	1,200,000
Chestnut	700	850	950	90	1,000,000
Cottonwood, common and black	500	650	800	80	900,000
Cypress, bald	900	1,100	1,300	100	1,400,000
Douglas fir (western Washington and Oregon) [2]	1,000	1,300	1,500	90	1,600,000
Douglas fir (Rocky Mountain type)	700	900	1,100	85	1,200,000
Elm, cork	1,000	1,300	1,500	125	1,300,000
Elm, slippery and white	800	900	1,100	100	1,200,000
Fir, balsam	600	750	900	70	1,000,000
Fir, commercial white (white, noble, grand)	800	900	1,100	70	1,200,000
Gum, black and cotton	800	900	1,100	100	1,200,000
Gum, red	800	900	1,100	100	1,200,000
Hemlock, western	900	1,100	1,300	75	1,400,000
Hemlock, eastern	800	900	1,000	70	1,100,000
Hickory, true and pecan	1,200	1,500	1,900	140	1,800,000
Larch, western	900	1,100	1,200	100	1,300,000
Maple, sugar and black	1,000	1,300	1,500	150	1,600,000
Maple, red and silver	700	900	1,000	100	1,100,000
Oak, commercial red and white	1,000	1,200	1,400	125	1,500,000
Pine, southern yellow [2]	1,000	1,300	1,500	110	1,600,000
Pine, white, sugar, western white, western yellow	750	800	900	85	1,000,000
Pine, Norway	800	1,000	1,100	85	1,200,000
Poplar, yellow	800	900	1,000	80	1,100,000
Redwood	800	1,000	1,200	70	1,200,000
Spruce, red white, Sitka	800	900	1,100	85	1,200,000
Spruce, Engelmann	500	650	750	70	800,000
Sycamore	800	900	1,100	80	1,200,000
Tamarack, eastern	900	1,100	1,200	95	1,300,000

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[1] Working stresses for Extra Select (S1), Extra Select (S1) Dense, Standard (S3), and Common (S4) grades are obtained by multiplying the basic stress by 7/6, 8/6, 5/6, and 4/6, respectively.

[2] The working stresses of any grade of timbers of Douglas fir and southern yellow pine which meet the density requirements of the American Society of Testing Materials shall be increased one-sixth the allowable stress given in the table for the basic or Select (S2) grade.

Table 1.—*Working stresses permissible for structural timbers of select (S2) grade*—Con.

[Pounds per square inch.]

Species.	Compression.					
	Allowable stress parallel to grain "Short Columns"[3] for Select (S2) grade.			Allowable stress perpendicular to grain for all grades.		
	Wet location.	Dry outside location.	Dry inside location.	Wet location.	Dry outside location.	Dry inside location.
Ash, black	500	550	650	150	200	300
Ash, commercial white (green, biltmore, white)	900	1,000	1,100	300	375	500
Aspen and large-tooth aspen	450	550	700	100	125	150
Basswood	450	550	700	100	125	150
Beech	900	1,100	1,200	300	375	500
Birch, paper	450	550	650	100	150	200
Birch, yellow and sweet	900	1,100	1,200	300	375	500
Cedar, Alaska	650	750	800	150	200	250
Cedar, western red	650	700	700	125	150	200
Cedar, northern and southern white	450	500	550	100	140	175
Cedar, Port Orford	750	825	900	150	200	250
Chestnut	600	700	800	150	200	300
Cottonwood, common and black	450	550	700	100	125	150
Cypress, bald	800	1,000	1,100	225	250	350
Douglas fir (western Washington and Oregon) [2]	850	1,000	1,100	200	225	325
Douglas fir (Rocky Mountain type)	700	800	800	200	225	275
Elm, cork	900	1,100	1,200	300	375	500
Elm, slippery and white	650	750	800	125	175	250
Fir, balsam	500	600	700	100	125	150
Fir, commercial white (white, noble, grand)	650	750	800	150	200	300
Gum, black and cotton	650	750	800	150	200	300
Gum, red	650	750	800	150	200	300
Hemlock, western	800	900	900	200	225	300
Hemlock, eastern	600	700	700	200	225	300
Hickory, true and pecan	1,000	1,200	1,500	350	400	600
Larch, western	800	1,000	1,100	200	275	325
Maple, sugar and black	900	1,100	1,200	300	375	500
Maple, red and silver	600	700	800	200	250	350
Oak, commercial red and white	800	900	1,000	300	375	500
Pine, southern yellow [2]	850	1,000	1,100	200	225	325
Pine, white, sugar, western white, western yellow	650	750	750	125	150	250
Pine, Norway	700	800	800	150	175	300
Poplar, yellow	600	700	800	125	150	250
Redwood	750	900	1,000	125	150	250
Spruce, red, white, Sitka	650	750	800	125	150	250
Spruce, Engelmann	450	550	600	100	140	175
Sycamore	650	750	800	150	200	300
Tamarack, eastern	800	900	1,000	200	225	300

[2] The working stresses of any grade of timbers of Douglas fir and southern yellow pine which meet the density requirements of the American Society of Testing Materials shall be increased one-sixth the allowable stress given in the table for the basic or Select (S2) grade.

[3] The influence of knots on compressive strength of columns of constant cross section decreases as the length increases. When the length reaches 30 times the least dimension, knots such as are allowable in Select (S2) timbers have no appreciable effect on the strength as a column.

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